

Technology Readiness Level Elevation of the Enceladus Organic Analyzer for Outer-Planetary in situ Organic Analysis (EOA)

Completed Technology Project (2016 - 2020)



Project Introduction

Outer-planetary icy moons like Enceladus and Europa have become enticing targets for future space exploration due to their subsurface oceans and hydrothermal vent systems. Quantitative and compositional analysis of organic molecules in these subsurface oceans would provide detailed information on formation, habitability, and on-going planetary processes of these bodies. The Enceladus Organic Analyzer (EOA), a small, lightweight, low-power payload designed for in situ organic molecule detection, would have the capability to collect and analyze samples from the hydrothermal jets of Enceladus by using a novel high-velocity capture plate coupled to the separation/detection technique of microcapillary electrophoresis laser-induced fluorescence (μ CE-LIF). The μ CE-LIF technique enables sub part-per-trillion (ppt) quantitative compositional analysis of amines, amino acids, carboxylic acids, fatty acids, aldehydes, ketones, thiols, and polycyclic aromatic hydrocarbons. Additionally, prototype miniaturized μ CE-LIF instruments have been built and field-tested for Martian exploration. Here, we propose to build and test a μ CE-LIF prototype that could fit into a standard 1U CubeSat while maintaining sub-ppt sensitivity, high resolution separations, and low power consumption. The overall goal of the EOA will be to collect, analyze, and quantify the organics contained within the jets of Saturn's moon Enceladus. To accomplish this goal, a subset of technology objectives must be met. Microdevices for on-chip analyses must function after a 10+ year storage period, the optical, high voltage, and pneumatic valve systems must be adapted for a 1U CubeSat, and a capture mechanism for plume particles must be developed. Once completed, these systems must be integrated, robustly connected, and fully tested on laboratory standard and analogue samples. Methodology First, I will demonstrate 10+ year old microdevice functionality through valve opening and functionality experiments. When the microdevices are shown to be functional, I will design, build, and test a miniaturized integrated optical system based on an optical stack as pioneered by the Mathies lab at UC Berkeley. I will extend this method using indium bump bonding to permanently weld each optical component together for the purpose of stability maximization. I will conduct organic analysis using a benchtop μ CE-LIF system to support capture media design and selection. I will assist in the design and build of the pneumatics and high voltage systems and will lead testing of the integration of each subsystem after construction is completed. Significance The EOA can directly accomplish the task of searching for biosignatures such as amino acid chirality and carboxylic acid chain length distributions. Organic analyses of these plumes could supply new evidence for the potential for life elsewhere in the Solar System. In addition, the μ CE-LIF technique allows for a broad range of planetary targets due to its highly adaptable, one-size-fits-all nature. While the internal μ CE-LIF components would remain unchanged, only the sample extraction mechanism would need to be altered to analyze a specific planetary environment. Here, the high velocity capture plate is a mission-specific feature for organic molecule extraction in a tenuous atmosphere environment. The completion of the proposed methodology in this



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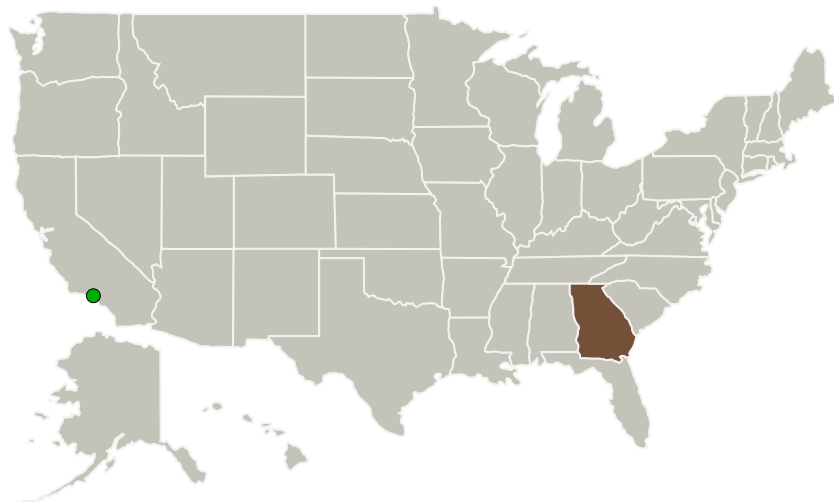


proposal for the capture plate will increase from TRL 1 to TRL 5. The completion of the proposed methodology for the μ CE-LIF components will also increase from TRL 1 to TRL 5 due to the novel miniaturization and permanent indium bump bonding processes.

Anticipated Benefits

Quantitative and compositional analysis of organic molecules in the subsurface oceans of outer-planetary icy moons would provide detailed information on formation, habitability, and on-going planetary processes of these bodies.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Georgia Institute of Technology-Main Campus(GA Tech)	Lead Organization	Academia	Atlanta, Georgia
● Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations

Georgia

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Georgia Institute of Technology-Main Campus (GA Tech)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Amanda Stockton

Co-Investigator:

Zachary Duca

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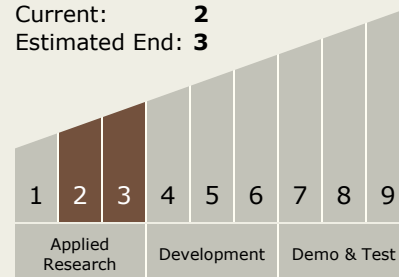


Project Website:

<https://www.nasa.gov/strg#.VQb6T0jJzyE>

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX04 Robotic Systems
 - └ TX04.3 Manipulation
 - └ TX04.3.4 Sample Acquisition and Handling

Target Destination

Others Inside the Solar System